



Experimental wheat area of CIMMYT near the town of Ciudad Obregon, Mexico.

# Wheat response to drought

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*Measurement of drought sensitivity helps evaluate wheat cultivars for bad as well as good conditions.*

One of the greatest limitations on wheat production worldwide is inadequacy of available water. Therefore, it is important to know how the crop is physiologically affected by drought and which cultivars produce best under stress. Such information is also useful in selecting and evaluating cultivars in wheat breeding programs.

Cultivars developed under optimum irrigation regimes often do not produce the best yields under water stress. Where water is limited (because of low rainfall or insufficient water for irrigation), it is just as important to know the relative yield loss specific cultivars may suffer in a drought as it is to know optimum yield levels that might be expected under ideal conditions.

Field experiments on wheat stress physiology and yield interrelationships were conducted for two years by scientists from the University of California, Riverside, in cooperation with Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center or CIMMYT). The work was done in the Mexican Sonoran Desert at the Centro Investigaciones Agrícolas Noroeste (CIANO) field station of the Instituto de Investigaciones Agrícolas, Secretaría de Agricultura, Mexico, near the town of Ciudad Obregon.

Numerous soil and plant water status measurements were made to characterize the severity of the treatments imposed. Of special interest were measurements of xylem pressure potentials ( $\Psi_x$ ) for plant water status, soil water content, and, of course, yield. Twelve bread wheat and durum wheat cultivars were examined, along with two triticales. Of these twelve, three—Cocorit 71, Yecora 70, and Gabo—were observed more intensively

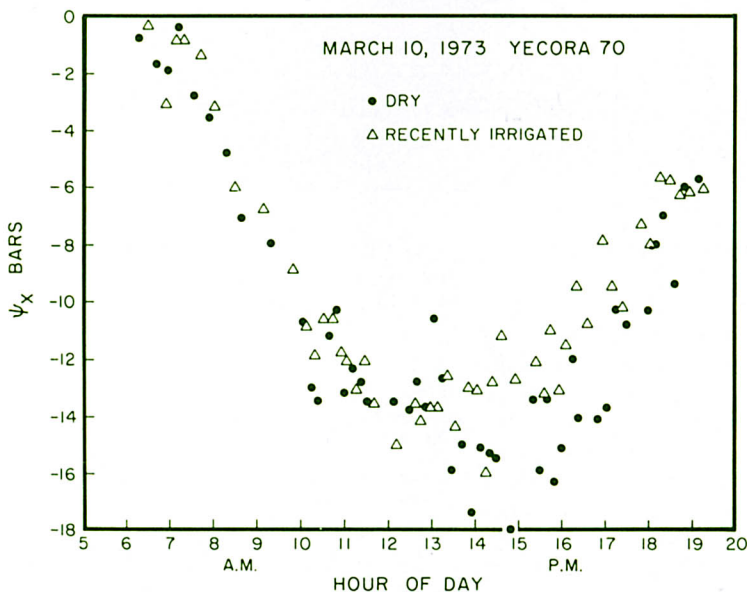


Fig. 1. Typical xylem pressure potential ( $\Psi_x$ ) daily response pattern for wheat.

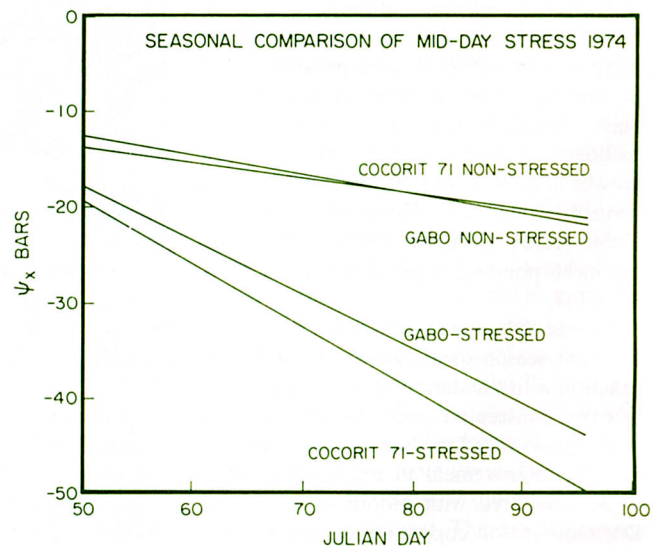


Fig. 2. Observations during growing season compare relative stress of a given cultivar under uniform soil-water regimes.

because of their expected range of response under stress. Interestingly, cultivars in any given stress treatment did not differ markedly in water use, but well-irrigated controls required about 2½ times as much water as did plants in any of the stressed treatments. Soil water regimes were nearly identical for all the cultivars in any given stress treatment.



Measurement of xylem pressure potentials of wheat varieties by Robert Sojka.

(Xylem pressure potential, or plant water potential, is a measure of the energy status of water in the conductive xylem tissue of plants, as determined in a pressure chamber. If a plant is neither gaining nor losing water due to environmental forces, the water potential is zero. If the plant is in equilibrium with environmental forces that would cause a net loss of water, the water potential is

negative, or less than zero. When soil is dry and the plant is actively transpiring water to a dry atmosphere, the degree to which the plant is stressed is indicated by how negative its water potential becomes. When two plants in the same environment have different water potentials, the plant with the less negative potential has some mechanism for resisting stress.)

It was determined that daily stress patterns (fig. 1) could be expressed statistically as three linear phases of  $\Psi_x$  response. In the morning  $\Psi_x$  began to drop (become more stressed) until about 10:00 a.m. After 11:00 a.m.  $\Psi_x$  ceased to drop, stabilizing until about 4:00 p.m., after which stress relief was evident and  $\Psi_x$  began to rise. The stable response period from 11:00 a.m. to 4:00 p.m. each day was long enough to allow numerous replicated observations of treatment and cultivar responses. These responses have been compared to evaluate the relative influence of stress on each cultivar over the treatment range.

As the season progressed, the daily responses during the stable midday periods resulted in relationships like those shown in figure 2. These types of data were used to show differences in the effect of soil water regime on development of physiological stress in the cultivars. For example, Cocorit 71 encountered much greater stress than Gabo in the second season of the study.

As each day passed, daily responses reflected the increased severity of stress in the nonirrigated treatments. Eventually, a point was reached when  $\Psi_x$  did not return to near zero values before dawn as was observed in figure 1. Instead, the plants were forced to enter succeeding daily cycles without full

recovery. Thus, recovery (or presunrise)  $\Psi_x$  showed increased stress as the season progressed (fig. 3). Again, Cocorit 71 was the most stressed variety in the predawn comparison. Seasonal rankings of  $\Psi_x$  response paralleled the percent yield loss among cultivars. In general, the greater percentage of yield losses occurred in cultivars that suffered the lowest seasonal  $\Psi_x$ .

A final and perhaps most significant finding was the degree of sensitivity of wheat yield to full presunrise recovery of  $\Psi_x$ . When presunrise recovery values fell to -7 bars, the yield loss, when compared with controls, was about 80 percent (fig. 4). As presunrise  $\Psi_x$  continued to fall to nearly -40 bars, only an additional 20 percent yield loss occurred. This finding underscores the importance of at least a brief period of recovery of  $\Psi_x$  to near zero each morning. Plants thus regain full cell turgor, which allows for cell growth and expansion and ultimately attainment of full crop yield potential.

These data indicate that plant water status measurements have a genuinely important role in evaluation of wheat cultivars for response to drought.

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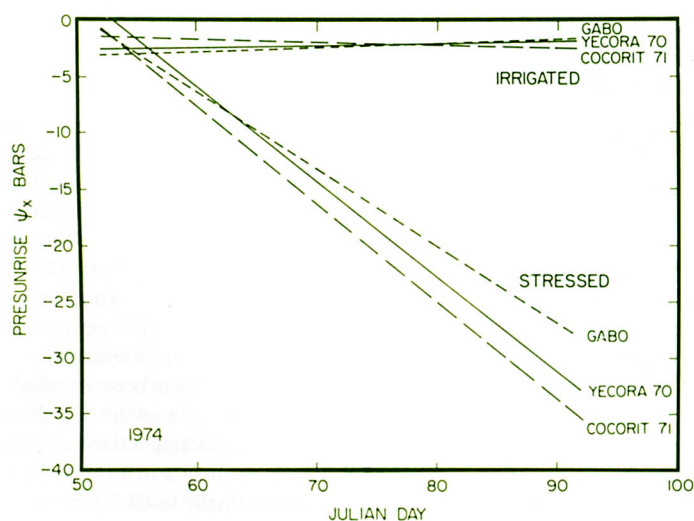


Fig. 3. By dawn, irrigated wheat recovered from previous day's stress; nonirrigated wheat had increasingly lower water potentials.

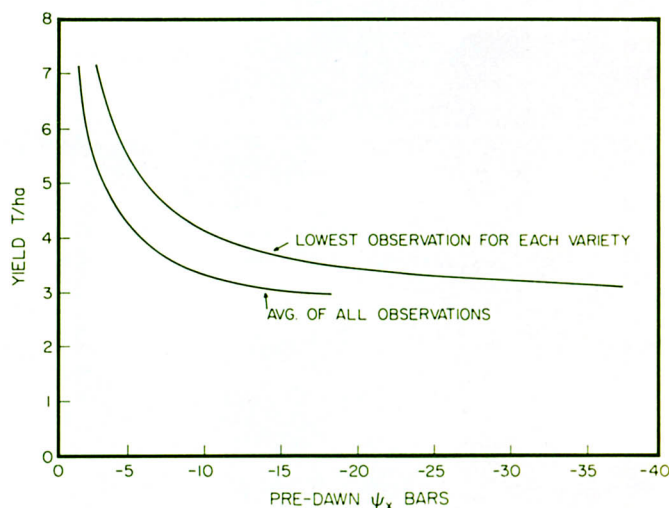


Fig. 4. Yields were highly sensitive to pre-dawn water potential; the first increments of stress took the greatest toll.